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THE LANTIRN PAPERLESS DEPOT
A COMPUTER-INTEGRATED REPAIR SYSTEM

Larry B. Alexander
Martin Marietta Electronic Systems
Orlando, Florida
and
Richard A. Wartenberg
LANTIRN Systems Program Office
Wright-Patterson Air Force Base

ABSTRACT

One of the premier technological programs in the Air Force today is the Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) system. This major program currently being fielded for our tactical forces represents advanced electronics technology not only in the weapon system itself but also in its support equipment.

This paper describes four major logistics support initiatives of the LANTIRN program that are joined together to form a Computer-Integrated Repair (CIR) system. This system will effect a paperless automated depot maintenance environment for LANTIRN. The system automates the maintenance concept across all levels of test and repair (Organizational, Intermediate, and Depot) and integrates the results into a comprehensive Depot logistics repair system. The CIR system will greatly improve the maintenance support of the LANTIRN depot and the reliability and maintainability of the entire LANTIRN weapon system.

INTRODUCTION

The LANTIRN prime mission hardware applies advanced technologies such as electro-optics, radar, and high-speed computers packaged together in two pods that attach beneath the fuselage of the F-15E and F-16C/D fighter aircraft. The LANTIRN pods enable fighter pilots to fly beneath enemy radar coverage, under the weather, and in total darkness.

A system with such sophisticated technology requires similar sophistication for its design, manufacture, and support. When planning the production program, it was evident that a production environment that provided timelv and accurate program information would be required to build LANTIRN. The system would need tight production control, information management, and should be computerized and paperless whenever possible. A set of requirements for a Computer-Integrated Manufacturing (CIM) system was developed and the creation of the paperless factory began. Today, this system, Aerospace Planning, Execution, and Control System (APECS™)*, is fully operational in LANTIRN production.

Since implementing APECS has been so highly successful, the transition into a paperless repair environment was a logical progression. A joint technical team from the LANTIRN Systems Program Office (SPO), Warner Robins Air Logistics Center (WR-ALC), and Martin Marietta was formed to define and specify the requirements for a Paperless LANTIRN Automated Depot (PLAD). As the PLAD initiative developed, three other logistics improvement initiatives were spawned to enhance and complete the system's design. The first was the Fielded System Status/Analysis (FSS/A) system. The second was the Data Logging Module (DLM); the third, the Computer-Based Technical Order (CBTO) system. Integrated, these four systems represent the necessary elements for a CIR system and implement an innovative approach to depot level logistics maintenance in a paperless environment.

PAPERLESS REPAIR ENVIRONMENT

The need for a paperless repair environment at the depot maintenance level is quite evident when studying current maintenance operations. Right now, several Depot Maintenance Data Systems are in use at WR-ALC. They include requirements systems, material systems, production systems, cost systems, and several other interfacing systems. Individual access through different computer terminal types with complicated data entry is required to use these systems. This procedure has resulted in a proliferation of terminals and a reduction of efficiency throughout the Airborne Electronic Division. Due to Air Force requirements, inputs to present data systems are made only after a large amount of other paperwork has been generated. In addition, the need to provide adequate technical documentation and information at the repair center has also had this effect: The maintenance technician has become the focal point of interface when these paper-intensive documentation and data entry processes come together. Unfortunately, this extra involvement by the direct labor force has decreased its productivity by more than 40 percent according to some estimates. This negative impact on productivity can be attributed to many factors such as the high level of detailed and complex tasks, a complicated requisitioning process, time lost in data capture, the documentation process, and the suppression of creativity caused by forcing those who wish generally to avoid the paperwork process to become deeply involved in paperwork. As a result of this increased management paperwork and with the increase in weapon systems sophistication, higher skilled personnel are needed. All of these factors have contributed to an overall increase in Government general repair costs.

The need to evolve into a less paper-intensive, paperless digitized world is seen as another reason or opportunity to introduce CIR as the wave of the future. This paperless evolution can be seen in other forums as demonstrated by the Computer-Aided Acquisition and Logistics Systems (CALS) initiatives advocated by the Office of the Secretary of Defense. The Air Force Logistics Command (AFLC) is also evolving into a paperless, computer-integrated environment through several of its Logistics Management Systems (LMS) initiatives. These systems include the Core Automated Maintenance Systems (CAMS), the Depot Maintenance Management Information System (DMMIS), and the Reliability and Maintainability Information System (REMIS). To fully evolve into a paperless environment at the depot repair level, a cybernetic systems approach should be used that addresses the needs of the logistics process. This system should also be designed to complement, synergize, and leverage the CALS/LMS efforts. The CIR system design being fielded for LANTIRN at WR-ALC embodies this approach.

CIR APPROACH

The CIR approach is totally dependent on a large and powerful system of highly integrated computer systems at all echelons of maintenance. CIR, as shown in

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Figure 1, integrates multiple systems of hardware and software to perform functions such as:

1) End item tracking
2) Administration/workload management
3) Automated storage and retrieval
4) Repair processing
5) Digitization of technical data including videogenics
6) Integration of automatic test equipment
7) Employee certification
8) Communications/electronic transmission of data between all systems
9) Technical information collection, application, and analysis
10) Software processing
11) Failure data collection and analysis
12) Automated material handling.

All of these CIR elements are implemented through the LANTIRN program initiatives (FSS/A, DLM, CBTO, and PLAD). Together, they represent a total systems integration approach to implement a CIR system for the LANTIRN depot.

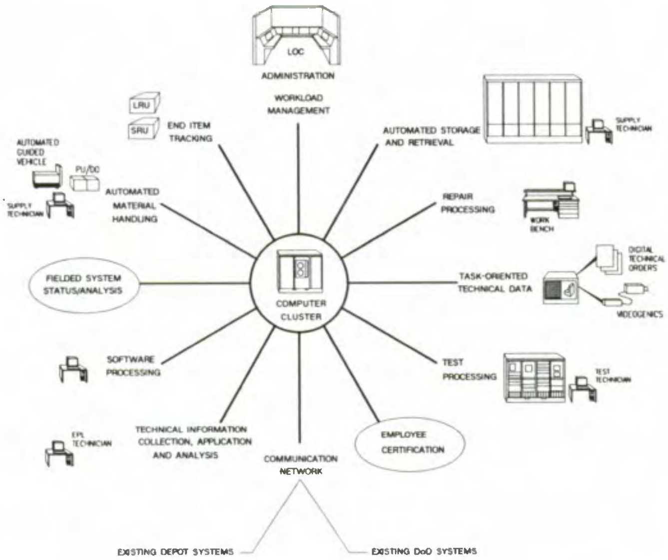

Figure 1. Computer-Integrated Repair

FSS/A - FIELDED SYSTEM DATA COLLECTION

In today's Air Force, data collection systems for detailed test history information collection are either incomplete, inaccurate, or nonexistent. The lack of complete and valid test history data on a failed item has frustrated the depot maintenance technician. Incomplete information often inhibits the technician's ability to implement the most comprehensive and longest lasting repair action.

To rectify this problem, the LANTIRN program is fielding a new concept in field information data collection. This concept, defined as FSS/A, was designed around the computer technology and interfaces available in the existing support equipment systems. By retrofitting some minor hardware changes and incorporating several software programs, the FSS/A system has automated the collection, storage, processing, and data management of detailed logistics and test parametric data from the LANTIRN ATE at the O, I, and D maintenance level. The system integrates the computers into a network structure of information collection and processing. It also provides all necessary management and data validation tools to eliminate corruption of collected data.

The design began by modifying the Air Force MATE Control and Support Software (MCSS) being used on the LANTIRN ATE. A data collection function was added to the MATE TPS Test Executive (MTTE) and a few new language commands were added to the ATLAS compiler. To complete the data collection functions and to provide a standard look and feel to the operator interface, a set of software programs was developed to process and manage the total data collection efforts.

Figure 2 represents a generalized FSS/A system level diagram for all levels of maintenance. It depicts the electronic data flow that exists between the various system elements.

FSS/A SYSTEM

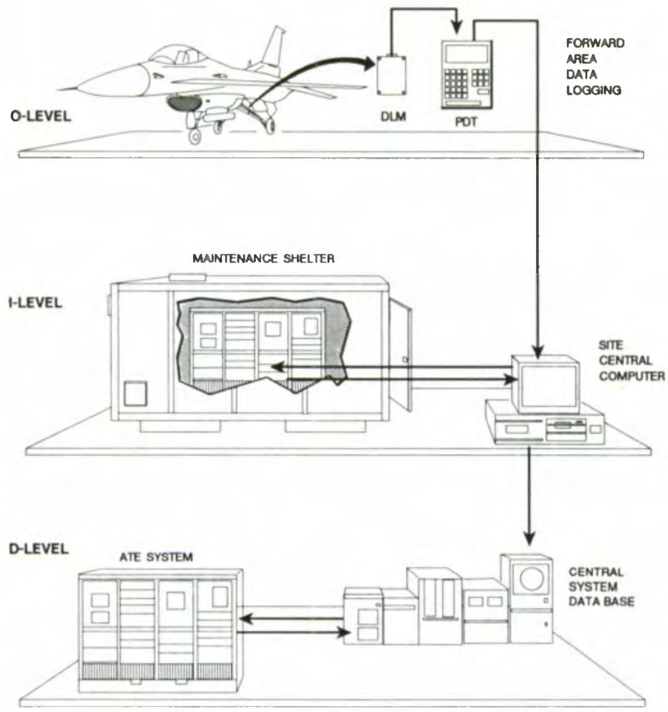

Figure 2. FSS/A Systems Diagram

A portion of the FSS/A system will be fielded at all LANTIRN operational bases to manage the information collection. At the intermediate maintenance level, a single workstation computer will serve as the site central collection point and as a central data base element for that particular LANTIRN wing or squadron. This site central computer will provide base level logistics/repair analysis and automate the transmission of all collected data to the Central System data base at WR-ALC. The collected data will provide WR-ALC logistics managers with timely and accurate configuration status tracking for all fielded hardware and software. For repair analysis, the use of all information collected by FSS/A will simplify and validate the repair process. Included in the FSS/A data base are such factors as:

1) UUT Part No. and Serial No.
2) Operational environment parameters
3) Time of test
4) Time of operation
5) All system faults
6) Repair actions
7) Technician responsible for UUT repair
8) Where the repair occurred

9) What equipment was used (Part No. and Serial No.)
10) Detailed pass and fail parametric values.

This data is stored in a relational data base and provides a complete maintenance test history from birth to death for all LANTIRN serialized items. Not only is the status of the prime mission equipment tracked, but all ATE systems are also tracked to status their maintenance problems and repair. In addition to its capability to status a failing component of the hardware or assist in repair, FSS/A also provides a logistics analysis capability that can be used to uncover design problems in the LANTIRN system. Components are often removed as a failing item because software (BIT/TPS) incorrectly identified them as suspect or an intermittent failure also occurred many times in the operation of the weapon systems. Further testing at the lower levels often does not duplicate the suspect failure; therefore, the item is returned to stock. The real failure was the fact that the BIT/TPS or the conditions under which the system was operated caused the fault. The FSS/A data base can be used to significantly reduce RETEST OK (RTOK) and CANNOT DUPLICATE (CND) diagnosis by providing detailed operational data that can be analyzed to determine the actual root cause circumstance(s).

The FSS/A system is being implemented to make this information available to all LANTIRN maintenance technicians (O,I, & D level). In this way, when a problem occurs that does not meet the normal repair scenario, the Air Force technicians will receive the information they need to make the best possible repair action.

DLM - WEAPON SYSTEM DATA LOGGING

Weapon systems today are generally computer-controlled and operated. A significant amount of detailed information is processed during the operational mission or during testing. This information is used by the system itself to diagnose problems and is not generally brought out of the system for additional analysis during ground maintenance operations. Such was the case with the LANTIRN pod. Lower level BIT data and flight profile parametric values were readily available in the system computer but no mechanism existed to store and retrieve this information until the Data Logging Module (DLM) initiative was introduced. The DLM provides the organizational level data collection functions and interfaces with the FSS/A system (see Figure 2). The DLM is an electronic memory module attached to the test interface connector of the LANTIRN system Advanced Pod Control Computer (APCC). This lightweight module was designed to serve as a passive element in the pod operation. During pod operation, the APCC collects flight information, mode change commands, and lower level built-in-test diagnostic data, and stores this information in the DLM memory. Following completion of the mission or during ground maintenance operations, the data can be retrieved and forwarded into the FSS/A site central data base by using a hand-held portable data terminal (PDT) computer. For flight line analysis, the data can be viewed with the PDT or the data can be combined with past maintenance histories stored in the FSS/A data base if more detailed analysis is required.

The DLM provides a level of maintenance information never before available to maintenance technicians. It captures the details of what was happening in the weapon system when a system failure occurs. The DLM information has proved valuable in troubleshooting the LANTIRN system and will be of great value to the depot level technicians in understanding failures and in validating their repair action.

CBTOs - DIGITAL TECHNICAL DATA DISPLAY

A Computer-Based Technical Order (CBTO) System has been developed to further support the paperless environment of the LANTIRN Depot. The CBTO system provides an interactive real-time digital display system on a Personal Computer (PC)-based workstation. The heart of the CBTO system is a software program that accepts remotely-produced technical order (TO) text and graphics data and stores both in a unique relational task-oriented data base. CBTOs retain the identity of the source data internally but create a single task-oriented data base and present to the user a seamless interface to the data. To the user, the outward appearance on the display is a simple man-machine interface using a single menu bar and several small pulldown menus. The system is interactive with the user via touch screen mouse operation. CBTOs provide a high resolution graphics display for viewing detailed line drawings. Figure 3 depicts the CBTO system design concepts.

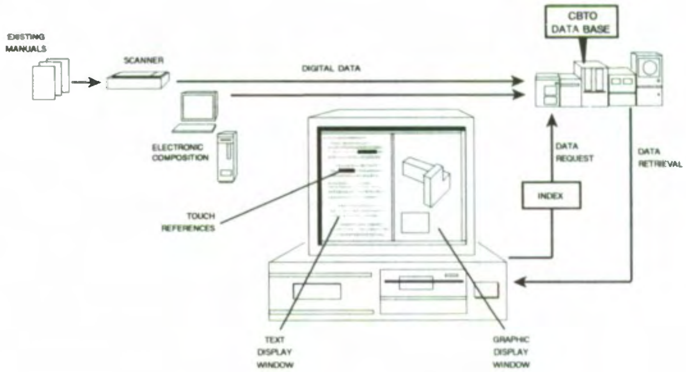

Figure 3. CBTO Systems Design

Using the CBTO system within PLAD will result in many unique operational capabilities. The technical data will provide the individual with technical instructions in such a way that the job of ensuring technical compliance will be made much easier. Due to the split screen capability, data from several technical orders will be viewed simultaneously. Completed task operations will be electronically validated. Page markers will be placed electronically to recall a particular portion of a technical order at the touch of the screen. Automated paging to text-referenced figures or tables will occur at the touch of a highlighted reference marker on the screen. Since the depot technician will work at the PLAD terminal, every technician will effectively have his own set of depot technical orders. The CBTO system will support all standard equipment operational procedures and will also include overhaul instructions, illustrations parts breakdowns, and general shop practices.

PLAD- DEPOT REPAIR FLOOR AUTOMATION

The PLAD system initiative integrates all other initiatives into a comprehensive paperless depot repair operation. PLAD system software and hardware integrates all system elements by providing all networking and interface using a distributed computer system built around a central computer cluster and using PC workstations to interact with the technicians. All system and workstation software has been specified around the day-to-day operations of the depot maintenance repair processes.

A sophisticated automated material handling system

will be integrated into the repair process to improve material handling and management. This Automated Storage and Retrieval System (ASRS) will accommodate all temporary storage requirements of the LANTIRN repair shop floor. This material storage will include repair end items, shop replaceable units (SRUs) and line replaceable units (LRUs), components (bit and piece parts), special tools, and test adapters and cables. The ASRS will be coupled with a conveyance system using automated guided vehicles (AGVs) to move the material from the stocking areas to the work areas.

A centralized operation center will be used to provide more efficient administration and workload management in the PLAD system. This work area, the LANTIRN Operations Center (LOC), will provide real-time control and information on all LANTIRN repair activities on the repair floor. The LOC will satisfy shop floor management requirements and will be occupied by LANTIRN production supervision, planning, and scheduling personnel. The activities from almost any perspective can be supervised without leaving the LOC through the LOC display systems. When a technician requires supervisory or other assistance, he can request it electronically from the PLAD workstation. The LOC can then dispatch the appropriate supervision assistance or deliver whatever material may be required. The LOC will monitor the ASRS inventories, end items, component conveyance, workstation status, ATE operational status, general shop floor status, and system variance status reporting.

The LANTIRN technician workstations are the focal points of the CIR process. The technician today is not fully productive because he must spend too much time moving from system to system to interact with several different support systems. In the PLAD design, all work process requirements are addressed through the technician's terminal. After identifying the I.D. of the technician and the part number/serial number of the item to be repaired, several simultaneous actions occur. The required technical data is loaded into the PLAD workstation and the PLAD central computer-hosted TPS file is downloaded to the applicable ATE station. All of the appropriate test fixtures and special tools are picked by the ASRS system and are delivered by an AGV prior to the test start. The workstations will automatically display the appropriate TOs and will also provide videogenic training. Short video instructions can be reviewed on subjects such as:

1) Test station operations
2) Peculiar test equipment repair
3) General shop practices
4) Management communications
5) Safety
6) Security.

The hiatorical test result collected on the UUT by the FSS/A system will be available for analysis. In addition, office automation capabilities such as electronic mail and word processing will be integrated into all PLAD workstations.

ARTIFICIAL INTELLIGENCE and EXPERT SYSTEMS

The CIR system has a tremendous capability for expansion and enhancements. One CIR expansion area being evaluated for LANTIRN is to increase test performance and throughput of the depot ATE systems. A method now being investigated is to leverage off computing power and the information data base of failure statistics to provide technicians with built-in expert help. Implementations of neural networks, artificial intelligence (AI) and/or rule-based expert systems are being evaluated for applicability to test engineering. Expert systems in ATE are not very common and, in many cases, are not required for UUTs that are simple to test. Where the weapon system uses complex designs or requires precision measurements and alignments, an expert system could greatly enhance the test sequence processing and shorten an otherwise difficult and error-prone testing procedure. Some basic run time statistics show that a 20 to 80-percent reduction in test time is possible by using an AI system to reorder the test program flow. This savings can be significant when complicated test procedures take several hours to complete.

The three integral parts of an AI system are the knowledge base system, the user interface, and the inference engine. In the CIR system, the use of the WR-ALC data system plus the PLAD and FSS/A data base could provide the knowledge system. The FSS/A software programs could easily be adapted to provide the user interface. This design would leave only the inference engine that could easily be hosted on the existing PLAD computer cluster or ATE system computers. As the CIR data base and analysis results grow, the AI system could be taught or simulated and the results could be used throughout the entire CIR network to improve performance and throughput of the depot systems.

BENEFITS

Implementation of the paperless depot will benefit the Air Force considerably. Integration of these depot program initiatives will automate the repetitious and redundant maintenance tasks, eliminate any associated paperwork burden on the maintenance operation, increase the knowledge base of system failure root cause, and free human efforts for other complex and diverse tasks. The overall efficiency and quality of the LANTIRN repair process will be greatly improved.

Through the use of a sophisticated automated material handling system, PLAD will reduce the need for human involvement in very simple and repetitive tasks of material movement. The current component acquisition/replacement time will be substantially reduced.

The proliferation of terminals needed to communicate with the existing WR-ALC computer systems will be eliminated by the PLAD system.

Stock will be maintained at efficient levels due to the improved data collection systems. The accuracy and timeliness of management information will be improved through real-time acquisition and analysis of depot repair data.

A savings will also be realized through the large reduction of paper products generated and stored internally at the depot.

The completeness and accuracy of historical failure test and repair data will facilitate design analysis for identification of inferior performance of parts, processes, and designs. Through use of this data, the product quality and reliability of the LANTIRN system will be improved.

SUMMARY

The operation of the Paperless LANTIRN Automated Depot will focus on integrating computer applications and automation for LANTIRN depot diagnostic and repair activities. Key initiatives include automating material handling and conveyance; integrating interactive workstations witn automatic test equipment; and collecting, processing, and displaying historical test results and repair data. Other features include displaying electronic technical orders and providing videogenics at the workstation. The implementation of

PLAD requires depot activation in fiscal year 1991. To ensure that PLAD is compatible with the Logistics Management System (LMS) initiatives, provisions are planned to integrate with these systems in the future and thus create an environment with greater efficiency and quality. As LMS initiatives become available for field use, they will be integrated into PLAD and thus result in a comprehensive, complementary management/ technical information system.

CIR is a highly integrated approach that leverages today's technology to benefit the repair domain in terms of higher productivity, potentially improved reliability, and enhanced product quality.

Under the guidance and management of the LANTIRN Systems Program Office, these initiatives have become a reality. As a result, a sophisticated Computer-Integrated Repair System is being developed for LANTIRN and the WR-ALC. The start-up risks involved in employing such a new concept on other programs in the Air Force have been considerably reduced. The concepts of CIR and its cybernetic systems approach is most certainly the next likely evolutionary step in the depot logistics modernization process.

*APECS - Trademark of Martin Marietta Corporation for manufacturing operational management systems